SimCube™ NIBP Simulator
Service Manual

In terms of the requirement of European Council Directive 2002/95/EC of 27 January 2003 (RoHS), SimCube NIBP Simulator Models SC-1, SC-2, SC-3, SC-4, SC-5, SimCube Battery Boost Option, power supplies and accessories are excluded in accordance with Article 2, Paragraph 1 as these products fall into Category 9, Annex 1A set out in Directive 2002/96/EC of 27 January 2003 (WEEE).

To dispose this product, contact Pronk Technologies at support@pronktech.com. We will issue a RMA and pay for return shipment.

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SimCube™ Service Manual

Models SC-1, SC-2, SC-3, SC-4 and SC-5

1. Overview

1.1 SIMCUBE OVERVIEW

The SimCube simulation system provides NIBP simulation in a small, portable, easy to use package. In addition to NIBP simulation, optional ECG, respiration and invasive blood pressure simulation are available. Combined with the Battery Boost option and the OxSim the SimCube family or products are the biomedical engineer's ultraportable tools of choice.

1.2 CALIBRATION OVERVIEW

Calibration of the SimCube is simple and may be done by qualified individuals by using the processes provided in this document. NIBP calibration is done via an access hole on the top of the SimCube. ECG R-wave calibration is done by lifting the faceplate and accessing the calibration potentiometer located on the ECG PCBA. IBP is calibrated at the factory with 0.1% resistors. If IBP calibration check yields the need for re-calibration, contact Pronk Technologies technical support for assistance.

1.3 WARRANTY

The SimCube has a three year warranty. Pronk Technologies provides many assembly level parts to repair the SimCube if it is out of warranty or if it is necessary to performs repairs outside of the factory. A list of parts is provided in this document.

1.4 SERVICE CAUTION

The SimCube is small, and so all the electronics, mechanics and pneumatics that make up the SimCube are compact and specifically routed. When opening up the SimCube care must be taken to note the routing and positioning of all harnesses, pneumatics and other assemblies. When reassembling these must be correctly re-positioned to ensure proper operation of the SimCube. If you have any questions, please feel free to contact us.

1.5 TECHNICAL SUPPORT

Pronk Technologies is dedicated to providing support to our customers in whatever manner they need. Our technical support staff are available by phone or email to provide help from operation level to component level. Whether it is an application issue, a service issue, or your thoughts about how our products could better fit your needs, we look forward to hearing from you.

2. SimCube Specifications

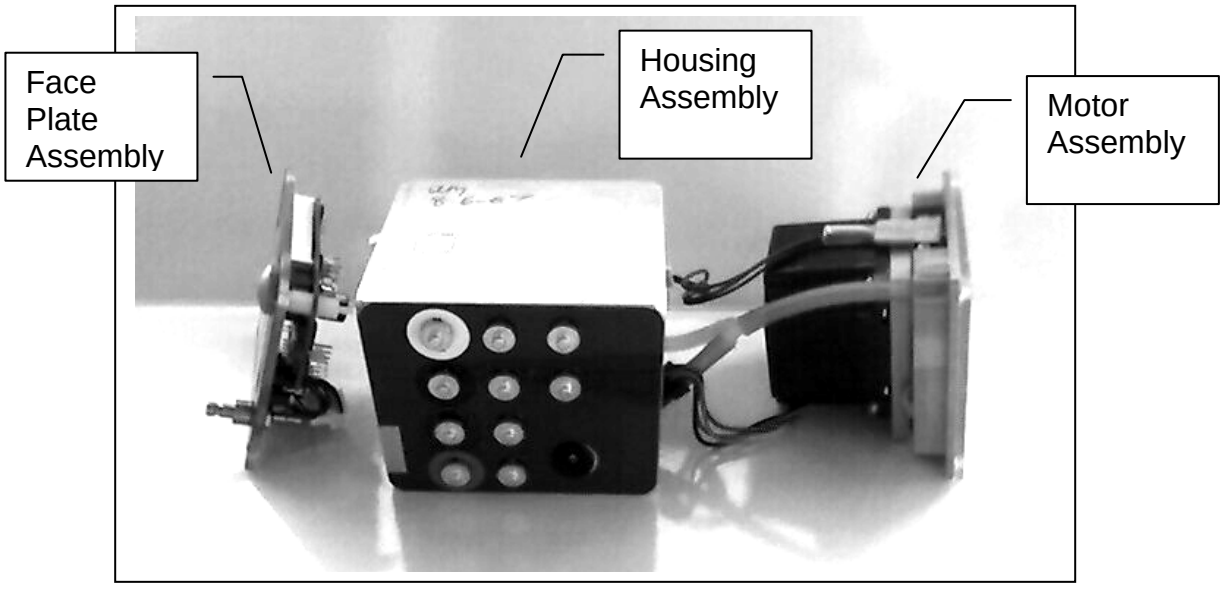
Physical Dimensions	
Size	3”x 3” x 3.5” (7.6cm X 7.6cm X 8.9cm)
Weight	2.5 Lbs
Power	External A/C Adaptor (Output: 6VDC / 2amps, 2.1mm, center positive connector) or 4 AA Batteries (with Battery Boost Option)
NIBP Connection	Quick Disconnect, Female
ECG/Resp Connection	10 ECG snaps
IBP Connection	Mini-DIN
Manometer	
Range	(SC-1, 2, 3, 4) 0 – 480 mmHg (SC-5) – 400 to + 400 mmHg
Precision	(SC-1, 2, 3, 4) 0.5 mmHg (SC-5) 0.1 mmHg
Accuracy	+/-1% of reading
User Interface	
Single Button Operation	
Operating Modes	Adult NIBP Neo NIBP Hypertensive NIBP Hypotensive NIBP (SC-5 only) Manometer Peak Detect (SC-3, 4, 5 only) HR Seq. Alarm Test (SC-4, 5 only) ECG Pace ON Arrhythmia Sequence (SC-5 only) Heart Rate Sequence (SC-4, 5 only) Invasive BP Zero (SC-5 only) Invasive BP 100, 200 (SC-5 only) Invasive BP Sequence (SC-5 only)
NIBP Adult Simulation	
Simulated Pressure	120/80 (100) mmHg
Simulated Heart Rate	70 bpm
Simulated Pulse Volume	1 ml
NIBP Neonatal Simulation	
Simulated Pressure	70/40 (55) mmHg
Simulated Heart Rate	95 bpm
Simulated Pulse Volume	0.5 ml
NIBP Hypertensive Simulation	
Simulated Pressure	190/120 (150) mmHg
Simulated Heart Rate	70 bpm
Simulated Pulse Volume	1 ml
NIBP Hypotensive Simulation (SC-5)	
Simulated Pressure	80/40 (60) mmHg
Simulated Heart Rate	70 bpm
Simulated Pulse Volume	1 ml
ECG Simulation (SC-2, 4, 5)	
Isolated	Yes
Synchronized with NIBP	Yes
R Wave Size	1mV (lead I) +/- 5%
R Wave Width	35 ms
Wave Shape	QRS wave

Connection	10 Snaps
Simulation Rates	70, 95, Asystole, Arrhythmia (SC-5), Pacer, HR seq. (SC-4, 5)
HR Sequence (SC4, 5)	
	30 seconds each of: 30, 60, 90, 120, 45, 160, and 220 bpm
Pacer Simulation	
Isolated	Yes
Synchronized with NIBP	Yes
Pacer Size	3 mV
Pacer Width	1.2 ms
Respiration Simulation	
Isolated	Yes
Synchronized with NIBP	Yes
Wave Shape	Square Wave
Size	4 Ohm
Rate	35 bpm (47 bpm for neonatal)
Simulation rates	20, 40, Apnea, Sequence = 00, 30, 45, 60, 22, 30, 80, 110.
Arrhythmia Simulation (SC-5)	
	Cardiac failure sequence: ~ 90 seconds of normal beats interspersed with PVCs and Runs, followed by ~20 seconds of VTAC, followed by ~35 seconds of VFIB, concluding with ~30 seconds of asystole.
Peak Detect	
Precision	0.5mmHg (SC-4) 0.1mmHg (SC-5)
Invasive Blood Pressure Simulation (SC-5)	
Isolated	Yes
Synchronized with NIBP	Yes
Excitation Voltage	DC range = 3.3 to 5.7 AC range = 6.65 to 11.4p-p
Pressure range	0-250 mmHg
Simulated Pressure accuracy	+/- 1 mmHg
Wiring	+ Excit = pin 1, - Excit = pin 4, + Sig = pin 3, -Sig = pin 6
Simulation rates	Dynamic = 120/80, 70/40, 190/120. Static = 0, 100, 200. Step = 0,25,50,100,150,200, 250
Environmental	
Voltage Range	100-240 VAC, 50-60 Hz

3. SimCube Mechanics

The SimCube is made up of three primary assemblies as shown below. These are:
The Face Plate Assembly. This includes:
The face plate and front decal
The Main PCB on standoffs
The pneumatic bulkhead
The IBP connector (SC-5 only)
The Housing Assembly. This includes:
The Metal housing
The power Jack
The ECG PCB and Snaps (if applicable)
The Motor Assembly. This includes:
The Motor
The NIBP plastic
The Interrupter PCBA
The pneumatic harness

These three assemblies are held together by 4 #6-32 screws which extend all the way through the unit from the back of the Motor Assembly and which are held in place with acorn nuts on the front of the Face Plate Assembly. The two screws nearest the ECG PCBA are insulated.

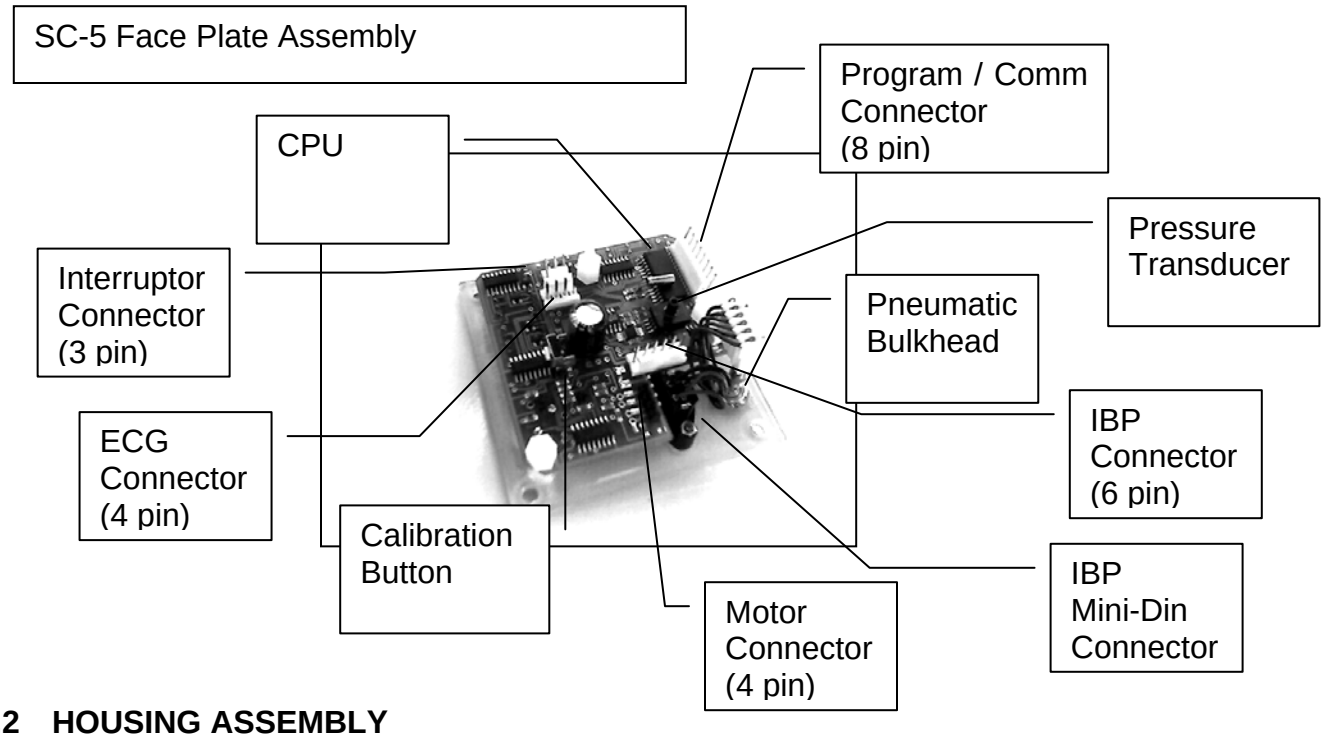


3.1 FACE PLATE ASSEMBLY

The Main PCBA assembly is mounted onto the Faceplate via three ¼ inch standoffs and when all the interconnecting wire harnesses and pneumatic assembly are disconnected,

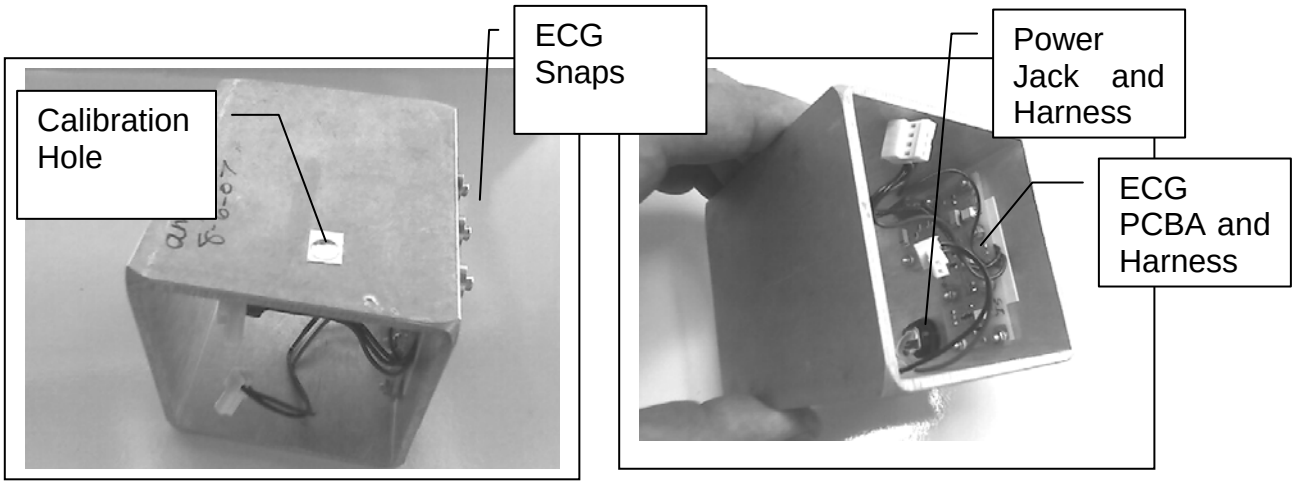
can be removed from the SimCube as a complete assembly. With the Face Plate Assembly removed from the unit, the main PCBA can be removed by removing the three plastic nuts holding it in place. There are two different main PCBA assemblies. The SC-1 through SC-4 Main PCBA is based on a PIC16F872, while the SC-5 SimCube is based on a PIC16F876.

A SC-5 Face Plate assembly is shown below. The layout of a SC-4 through SC-4 Face Plate assembly is the same except that that there is no IBP connector and the programming connector is populated differently. Also, the SC-1 through SC-4 use analog rather than digital calibration, so the Calibration switch is replaced with a calibration potentiometer.

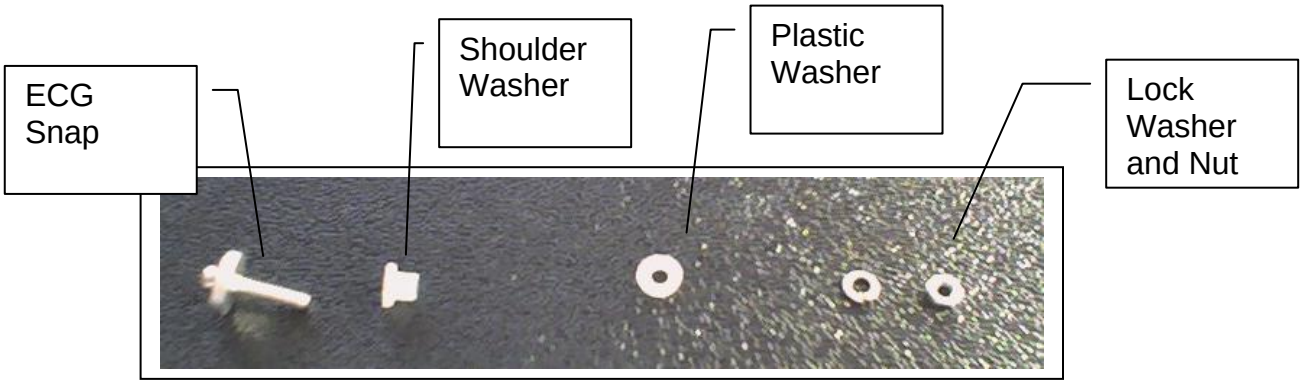


3.2 HOUSING ASSEMBLY

The housing assembly is shown below.



The ECG PCBA is mounted on the shafts of the snaps on the inside of the Housing Assembly. Note that for proper operation the ECG it must be electrically isolated from the rest of the assembly. Opto-couplers carry the signals across while keeping the ECG circutry isolated, but it is also critical to maintain the mechanical isolation between the PCBA and the aluminum housing. The correct stack up of mounting hardware to maintain this isolation is shown below. The snap feeds from the outside of the housing through a plastic shoulder washer. On the inside of the housing a plastic washer sits between the housing and the PCBA. On the top of the PCBA the snap is retained and held to the pad on the PCBA via a lock-washer and a #4-40 small pattern nut. Metallic contamination under the ECG PCBA on any of the plastic hardware can violate the electrical isolation and lead to reduced ECG performance.

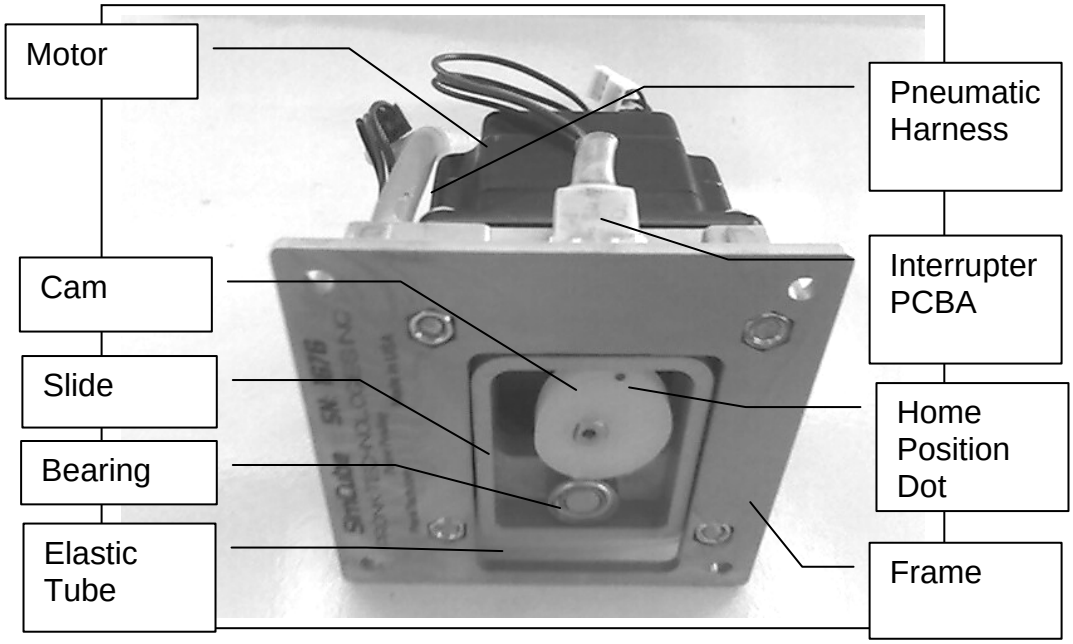


A calibration hole is provided in the top of the housing assembly to allow calibration of the manometer without disassembly of the unit. It can be accessed by lifting the foil tape.

On the wiring harness that comes from the ECG PCBA, Pin 1 or Red color wire is ECG, which contains the digitized ECG signal, Pin 3 or Blue color wire is RESP, which contains the digitized respiration, and Pin 2 or Green color wire is PACE, which contains the pacer artifact signal. Pin 4 or the black wire is ground.

3.3 MOTOR ASSEMBLY

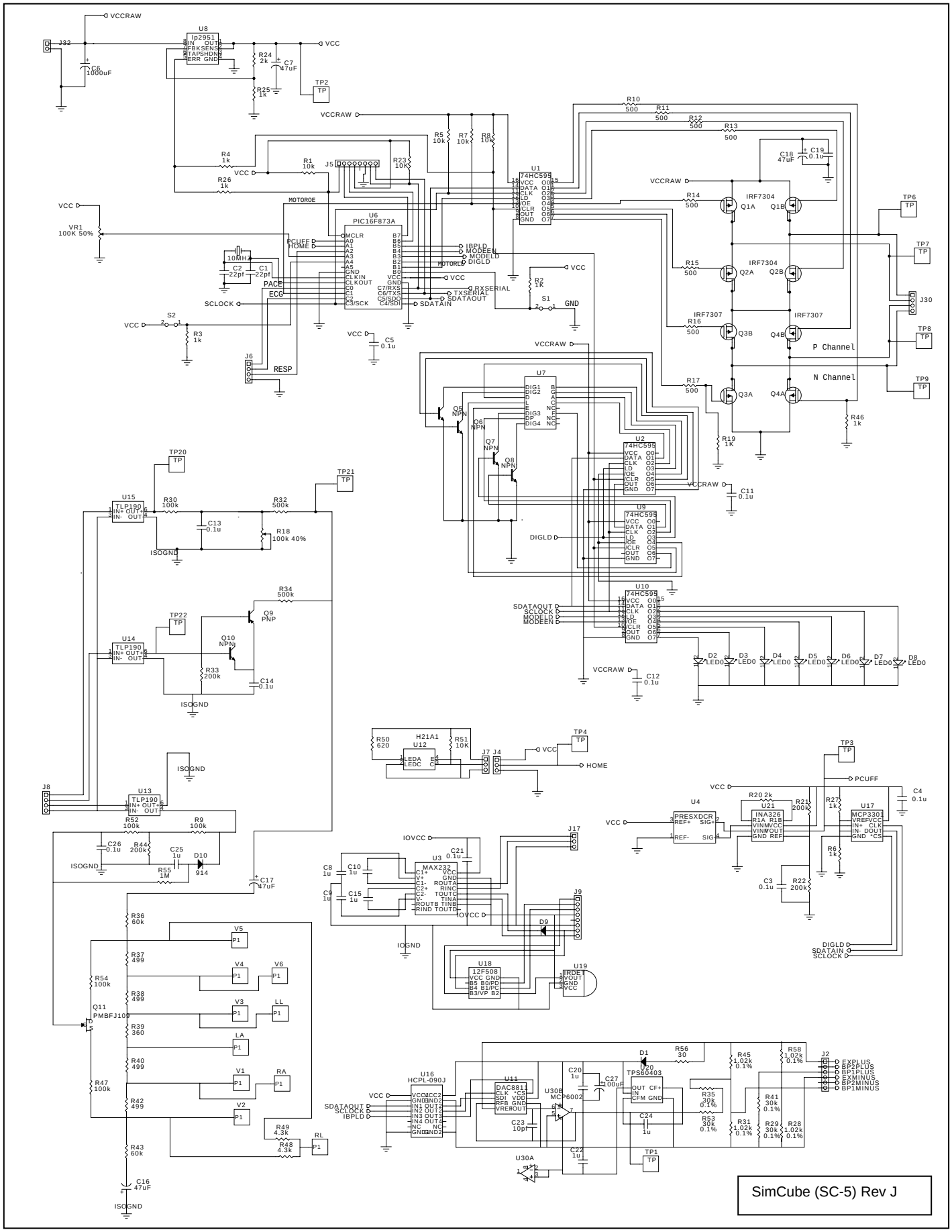
The Motor Assembly is shown below:



This assembly functions as follows: The Motor turns the Cam, which moves the Slide (via the bearing) and compresses the Elastic Tube, which creates pressure pulses. The pressure pulses are conveyed to the bulkhead and pressure transducer via the pneumatic harness. A tab on the top of the Slide breaks the beam of a photo interrupter, which is mounted on the interrupter PCBA. The Frame provides the structure for the assembly. The Cam is equipped with a home position Dot, which allows us to observe and express Cam position and movement. Cam position is expressed in terms of clock hands with the assembly oriented as shown. Normal home position (shown), for example, is usually between 12:30 and 1:30.

Note that all connections on the pneumatic harness are sealed with silicone glue to reduce any chance of leakage around the hose barbs on the fittings. If the harness is disassembled for any reason all joints that have been disturbed should re-glued.

4. SimCube Electronics



5.1 POWER SUPPLY

Input voltage (6V DC) comes in at J22 as VCCRAW which is used for running the motor and display. C6 prevents transient spikes on this Signal. VCCRAW is then regulated VCC (4.xx V) by U8.

5.2 MICROCONTROLLER

The microcontroller is clocked at 10MHz by X1, and held in reset until power is stable by U8.

5.3 DISPLAY AND USER INTERFACE

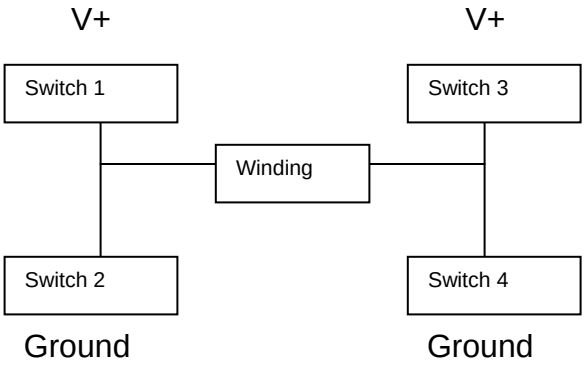
Numeric display data is presented to the 4 digit, seven segment display (U7) by serial to parallel latches (U2 and U2). Data is fed to the latches by the microcontroller via the SPI synchronous serial bus (SDATAOUT,SCLOCK). The mode display LEDs are also presented with data from a serial to parallel latch (U10) which is also on the SPI bus. S1 is the larger yellow button on the face of the unit.

5.4 PRESSURE MEASURMENT

Cuff pressure is measured the pressure transducer (U7), amplified by an instrumentation amplifier (U21) and then digitized to 13 bit resolution by the ADC (U17). The ADC communicates with the microcontroller via the SPI bus. There is no analog calibration adjustment, rather during the calibration process reference points are established and stored in EEPROM. The microcontroller coordinates this process via the use of the calibration push button, S2. VR1 is not installed on SC-5 boards.

5.5 MOTOR DRIVE

The SimCube uses a bipolar, 2 winding, 3V stepper motor. This means that during the step pattern progression the windings need not only to be turned off and on, but also to be reversed in polarity. This is normally done with switch configuration called a H bridge, and is illustrated below:



When the winding needs to be at a positive polarity Switch 1 and Switch 4 are turned on while Switch 2 and Switch 3 are turned off. When the winding needs to be at a negative polarity Switch 2 and Switch 3 are turned on and Switch 1 and Switch 4 are turned off.

The SimCube's motor windings are connected at J20, with the first winding between pin 1 and pin2 and the second winding between pin 3 and pin 4. Each winding has a H bridge, and the two windings are placed in series, so the H bridges are placed with one on top of the other. The FETs Q1 through Q4 form the actual switches. These are controlled by the serial to parallel latch, U1 which is run by the microcontroller via the SPI bus.

5.6 PHOTO-INTERRUPTER

The photo-interrupter is U12. It presents an analog output which represents how much of the light path in the interrupter is occluded by the tab on the top of the slide. This value is fed to an analog input on the microcontroller.

5.7 ECG SIMULATION

The ECG simulation circuit starts with the signals ECG, PACE, and RESP coming out of the microcontroller. The ECG signal is a pulse width modulated square wave, where the width of each pulse represents the correct amplitude of each R wave at any give point in time. The PACE signal is a narrow pulse which goes high when the simulated pacemaker is to fire and the RESP signal is a slow square wave which toggles value twice for each simulated breath. These signals are fed to the ECG PCB via J6 and J8.

Once on the ECG PCBA the three signals are sent across the isolation barrier formed by the opto-couplers U13, U14, and U15. Note that these opto-couplers are photo-voltaic: they generate an output voltage on the isolation side from only the light they receive from the non isolation side. This means that no isolation power supply is necessary.

The ECG signal comes across via U15. The PWM frequency is filtered out by R30 and C13, then the signal is gain adjusted via R18. The signal is then scaled down and fed to the ECG ladder formed by R37 through R42.

The pace signal comes across on U14. Note that this signal bypasses the low pass filter used by the ECG signal so that it can represent the higher frequency pacemaker signal.

The RESP signal comes across on U13. The signal is rescaled and processed to prepare it to drive the gate of JFET Q11. Q11, when on, switches a 200k parallel resistance across the ECG ladder effectively changing the resistance value of each resistor in the ladder.

5.8 IBP SIMULATION

Like the ECG circuit the IBP circuit is separately isolated. Also, like the ECG circuit, there is no specific isolation power supply. In the case of the IBP the supply is derived from the excitation voltage supplied by the monitor to the transducer. For most monitors the excitation voltage is a 5V DC signal, however some monitors use an AC excitation or a pulsed DC excitation. Support for these adds some complexity to this circuit.

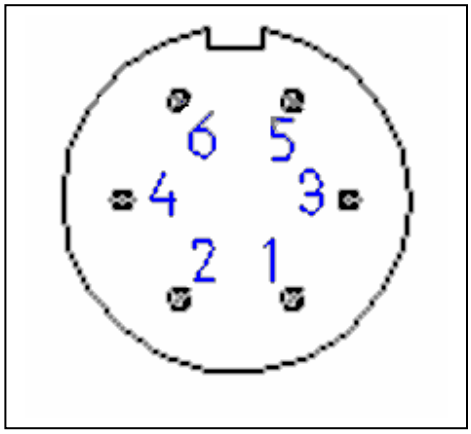
The excitation voltage comes in via J2 pin 1. It is buffered by R56, and peak captured by D1 and C27, forming a positive DC supply. This positive supply voltage is fed to the DAC (U11) and OpAmp (U30), and also to a charge pump inverter (U20). The charge pump inverter generates a negative supply voltage, which is also used by the DAC and OpAmp.

The DAC (U11) is controlled by the microcontroller via the SPI bus signals which are isolated by U16. The digitally programmed values are multiplied by the reference voltage (which is the excitation voltage) and presented as a current to U30 which transforms them to a negative voltage. So the signal at TP1 represents the desired BP value multiplied by the excitation voltage signal, and inverted. This signal is scaled down and biased to ½ of the

excitation voltage by the output resistor network and fed to the negative transducer signal output (J2 pin 6). The positive transducer signal output (J2 pin 3) is tied to ½ the excitation voltage. The negative excitation voltage is tied directly to IBP isolation ground on J2 pin 4.

The diagrams below show the pin-out of the IBP signals

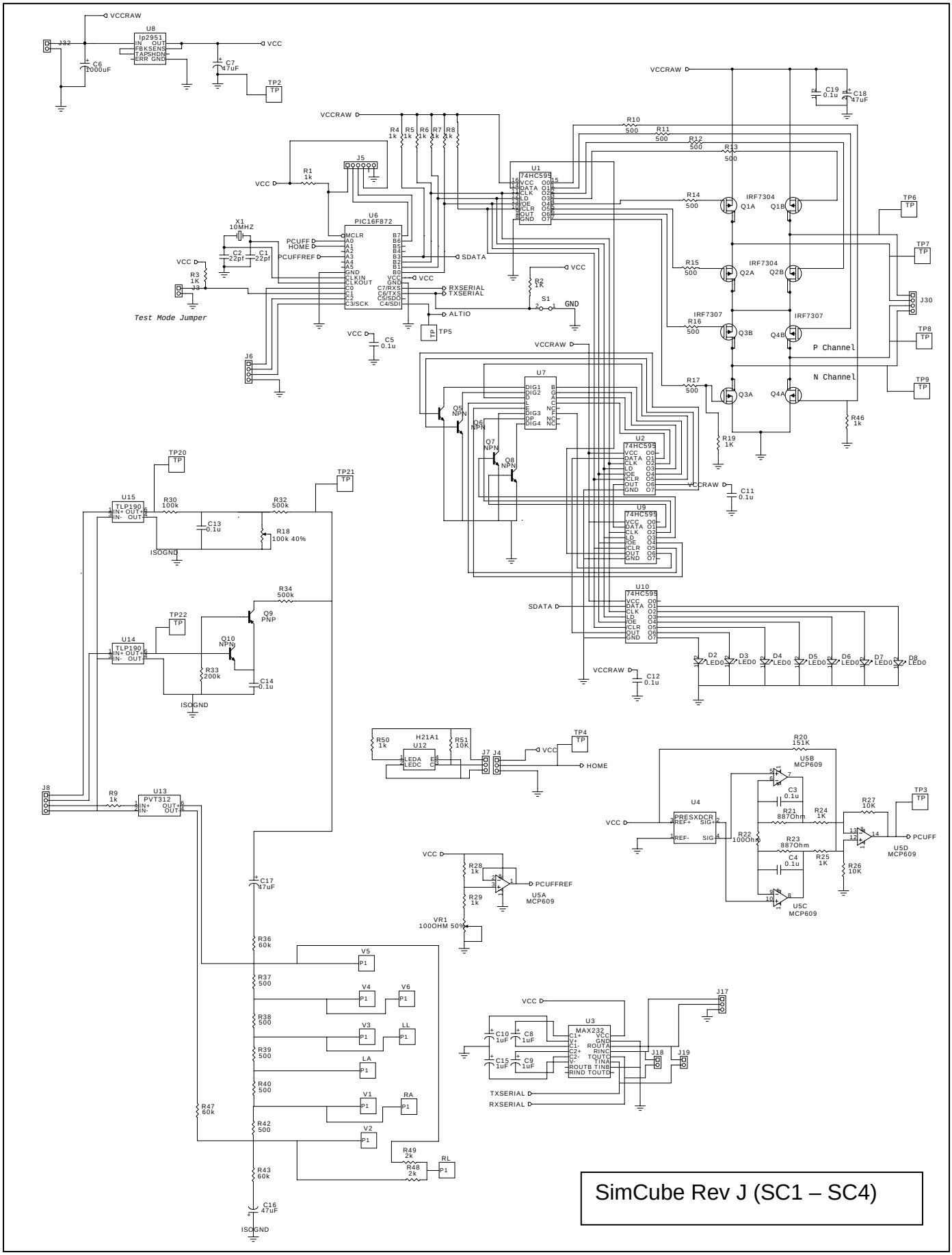
Signal Name	Pin Number
Excitation Plus	1
Excitation Minus	4
Signal Plus	3
Signal Minus	6
No Connect	2
No Connect	5



IBP connector pin-out
Looking at SimCube face

5.9 SC-1 THROUGH SC-4 VS. SC-5 ELECTRONICS DIFFERENCES

The schematic diagram for the PCBA used on the SC-1 through SC-4 is shown below. It is mostly identical to the SC-5 previously discussed, with the following exceptions:
There is no IBP Circuit
The instrumentation amplifier for the pressure transducer is made up of discreet opamps (U5), rather than being an integrated instrumentation amplifier.
The ADC on board the microcontroller is used to digitize the cuff pressure signal rather than a separate ADC as on the SC-5.
Manometer calibration is performed by using a potentiometer to modify a reference signal rather than by using the button to modify EEPROM constants as on the SC-5.


SimCube Rev J (SC1 – SC4)
Test Mode Jumper
P Channel
N Channel
VCCRAW
VCC
ISOGND
U8
lp2951
U6
PIC16F872
U1
74HC595
U2
74HC595
U7
U9
74HC595
U10
74HC595
U15
TLP190
U14
TLP190
U13
PVT312
U12
H21A1
U4
PRESXDCR
U5A
MCP609
U5B
MCP609
U5C
MCP609
U5D
MCP609
U3
MAX232
IRF7304
IRF7307
Q1A
Q1B
Q2A
Q2B
Q3B
Q4B
Q3A
Q4A
Q5
NPN
Q6
NPN
Q7
NPN
Q8
NPN
Q9
PNP
Q10
NPN
J5
J6
J30
J32
J4
J7
J8
J17
J18
J19
S1
GND
HOME
PCUFF
PCUFFREF
SDATA
RXSERIAL
TXSERIAL
ALTIO
LED0
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP20
TP21
TP22
X1
10MHZ
VR1
100OHM 50%
R18
100k 40%
V1
V2
V3
V4
V5
V6
LA
LL
RA
RL
P1

6. Basic Checkout

6.1 BOOT-UP SEQUENCE SEEN FROM THE FRONT

At boot up, the main PCBA will display software version number, then display four dashed lines while the manometer is zeroing to atmosphere pressure. The dashed lines will remain until the zeroing process is complete, typically four to 15 seconds. If the SimCube is not vented to atmosphere at boot-up, no further operation will be allowed, as the manometer cannot be considered reliable. Four dashed lines will be displayed until the transducer determines is atmospheric pressure. Once the zeroing process is complete the unit will show 000.0 on the display and the first of the mode indicator lamps will be lit. In the unlikely event that the EEPROM calibration values have been lost the unit will display 'CAL' instead of the dashes and the boot process will stop there.

6.2 BOOT-UP SEQUENCE SEEN FROM THE REAR

Also during boot up the stepper motor will rotate the cam clockwise one or two times to establish the home position for the cam. The home position is the cam orientation from which each simulated pulse will begin and end. See section 3.3 for a definition of home position. Home position will vary somewhat from unit but should always be in the range of 12:00 to 1:30. Looking for and understanding the home position at boot-up can tell you a lot about the operational status of your SimCube.

6.3 POWER CABLE AND JACK

Test the power jack and the strain relief on the input power cable by wiggleing input cable in the power jack and verifying that the unit does not reset.

6.4 MANOMETER

Attach a syringe or a hand bulb to the pressure port on the SimCube. Place the SimCube in Manometer mode and introduce pressure. Verify the that manometer responds correctly.

6.5 PULSE GENERATION

Attach a syringe or a hand bulb to the pressure port on the SimCube. Place the SimCube in Adult mode and inflate to 100mmHg and observe the cam motion. The cam should rotate from its home position (in the range of 12:00 to 1:30) to its peak position of 4:00 to 5:30 and back. During operation the cam should never move beyond the 6:00 position. See Section 3.3. It may be necessary to use a small volume to absorb the pulses made by the SimCube. If too small of a volume is used for this test it will be difficult to get the pressure to an accurate 100mmHg as it will be pulsing substantially.

6.6 ECG OPERATION

Connect the SimCube to the ECG lead wires of a known working patient monitor and verify the presence of ECG, pacer, and resp signals.

6.7 IBP OPERATION

Connect the SimCube (via the extender and provided adapter cable) to a known working patient monitor and verify the presence of the IBP signal.

7. SimCube Disassembly and Assembly

The SimCube is very small and compact. Being so small means that harnesses and pneumatic assembly must be specifically routed to avoid pinching or kinking the tubing. Please take note of routing during disassembly. When opening the SimCube the blue plastisol boot must first be removed. Take care to not catch the ECG snaps while removing the large boot.

7.1 REMOVING THE FACEPLATE ASSEMBLY

To remove the faceplate assembly that includes the Main PCBA, start by loosening and removing the acorn (cap) nuts at the front of the SimCube. Lift the faceplate off of the four inch, 6-32 screws that hold the SimCube together. Note harness and pneumatic placement before disconnecting and freeing the faceplate assembly. To completely remove the Main PCBA, loosen and remove the three nylon standoffs and if configured, disconnect the IBP harness. The Main PCBA should be completely free.

7.2 REMOVING THE HOUSING ASSEMBLY

If configured with ECG/RESP, the housing assembly will include the ECG PCBA. To remove the housing assembly, place the SimCube on the clear polycarbinate bottom. From above, place hands on outside of housing and push on the top of the motor assembly with your thumbs. The Housing should slide up and completely lift off of motor assembly.

7.3 REMOVING THE PNEUMATIC ASSEMBLY FROM THE MOTOR ASSEMBLY

To remove the pneumatic assembly it does not require you to remove the motor. Remove the small phillips screw and washer at the end of the assembly that holds the unit to the frame. Using a small slotted screwdriver pry the nylon elbow fitting up and out the channel. Then slowly pull the pneumatic assembly free of the frame.

7.4 REMOVING THE INTERRUPTER ASSEMBLY FROM THE MOTOR ASSEMBLY

It is important to note that removing the Interrupter assembly can affect the dynamic calibration of your SimCube. This should be done only with communication with Pronk Technologies technical support to ensure reading capture accuracy.

7.5 COMPLETE DIS-ASSEMBLY OF THE MOTOR ASSEMBLY

To remove the motor and gain access to the slide, loosen the four mounting screws holding the motor onto the assembly. Slowly lift the motor, cover and four mounting screws off of the rest of the assembly. Take note of any washers, their size and locations before going forward. This will help during re-assembly. Lift off the slide.

7.6 RE-ASSEMBLY TIPS

Please read these tips to help make your servicing successful. Because the SimCube is so small and compact, attention to detail during re-assembly can make all the difference.

7.6.1 Motor assembly

There are two important concepts to re-assembling the Motor assembly. First, the slide and frame must be cleaned and re-lubricated before re-assembly. It is important that there be no foreign particles that can find there way into the area where the slide rails meet the frame rails. Motor harness should be oriented to the front of the assembly, determined by the pneumatic harness large tube being in front. Second, be sure to clean motor mount screws of any thread locker or plastic before re-installing. Be sure to re-locate washers during re-assembly. Finally, because of the vibration during NIBP reading, we recommend applying thread locker on the motor mount screw and nut. ONLY use thread locker made for ABS material, as other thread locker chemicals may dissolve plastic materials.

As noted above, re-installing the interrupter assembly can have an affect on NIBP dynamic calibration. Please contact Pronk Technical support if interrupter requires re-installation.

7.6.2 Housing assembly

The single important thing here is to NOT pinch the pneumatic tubing while re-installing the housing assembly. The best way to avoid this is to turn the Cam at the back of the unit to the 9:00 position. This allows for maximum space for the pneumatic tube to lie in, away from the aluminum housing during re-installation. Once the housing is fully down onto the frame, tuck the pneumatic tube into a natural position and away from the polycarbonate bottom.

If configure with ECG/RESP be sure that the two long screws that hold the SimCube together and are on either side of the ECG PCBA have heat shrink on them to isolate them.

7.6.3 Faceplate assembly

Re-installing the faceplate assembly is about getting the harnesses correctly re-connected and closing the SimCube without pinching harnesses and ensuring that the harnesses do not get in the way of the pneumatic assembly potentially causing a kink in the tubing.

Start by having the rest of the SimCube assembled. This should include motor assembly, ECG housing assembly, bottom polycarbonate plastic and the four long screws. Place the SimCube on it’s bottom with the front facing the ceiling. Facing the SimCube, orient the faceplate assembly and start connecting the wire harnesses. The Red motor harness should be first and connected to the 4 pin non-locking connector. The correct orientation for the motor harness is for the wires to be pointing in towards the center of the PCB, NOT coming out off the PCB. All other connectors are keyed. Work your way through the power harness (2 pin) IBP harness (6 pin) ECG harness (4 pin) and interrupter harness (3 pin). After all the wire harness are connected, the last thing to connect is the pneumatic assembly. Refer to section 3.1.

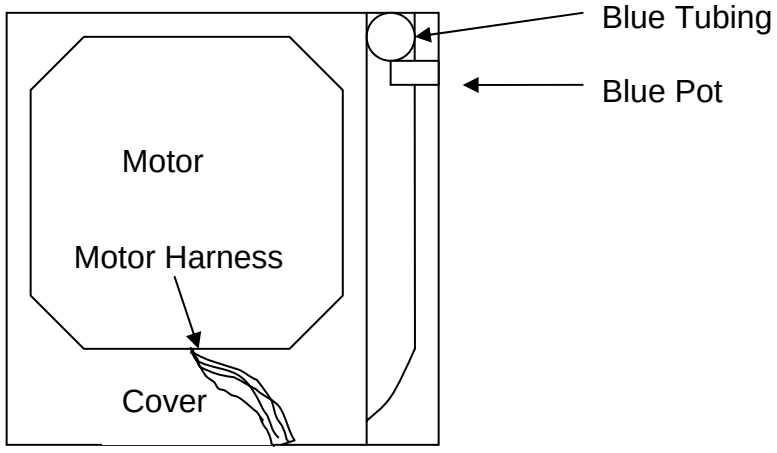
It is critical to SimCube operation that the pneumatic assembly is fully connected and, when the circuit is completed to the monitor, completely air tight. Ensure that the silicone tubing is fully engaged on to fittings.

For SC-5 platform: Route the blue tubing to the bulkhead connecter so that the ECG and power harnesses are pushed between the housing wall and the bulkhead connector and are tucked down between the motor and the ECG board. Ensure the blue silicone tubing is fully onto the bulkhead connector. Always connect the small clear/white tube to the transducer last, just before closing up to ensure connection. To connect small clear/white tube rout so that there are no wire harnesses in the area of the Y connecting the blue and clear tube. Ensure the clear tube is fully on to the transducer located in the center of the main PCBA.

For SC-1 through 4 platform: Pneumatic routing is slightly different with this assembly. Rout the blue tubing to the bulkhead connector so that the tubing is next to the housing wall and the ECG and power harness are on the opposite side of the bulkhead connector. Rout the wire harnesses off to the opposite side and out of the way of the pneumatic tubing.

For both platforms: One last, important task before closing up the SimCube; On the pneumatic assembly there is a 2.5 inch rise of blue silicone tubing that separates the Y and the L fittings. This part of the pneumatic tubing needs to the routed so that the tubing passes between the housing wall and the blue potentiometer as in the drawing below. This will help keep the tubing from kinking when the SimCube is closed. This is also a good time to check that all the above has been successfully implemented and to do a trial power up. If the SimCube comes up as expected, remove power and complete the assembly.

Finally, when closing up the SimCube ensure all harnesses and pneumatics are fully connected, then close the SimCube and replace the acorn or cap nuts. Connect the power supply again and check that there is no kinking in the pneumatics by blowing into the bulkhead connector. You should see the manometer move in response to the pressure change.



8. Calibration and Adjustments

8.1 MANOMETER CALIBRATION

8.1.1 Required Equipment

The following equipment is necessary:
A high quality reference manometer, capable of reading at least 0 to 500 mmHg (SC-1 through SC-4) or –420 to +420mmHg (SC-5) with an accuracy of at least 0.2mmHg over the measurement range. One option is Miriam's 'Smart Manometer' series. The reference manometer must have a valid, traceable, certificate of calibration.

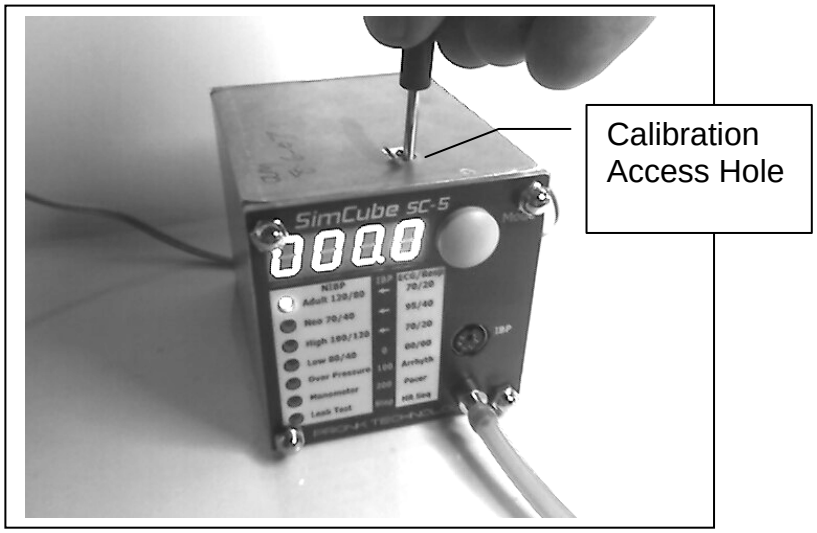
8.1.2 Manometer Calibration Process for SC-1 through SC-4

- Pre-check calibration at 50, 150, 200, 300mmHg, +/- 1%. Normally no adjustment will be required. Proceed with the following steps only if it is found that adjustment is required.
- Remove the SimCube's blue rubber boot.
- Power up SimCube for calibration and allow to warm up for 3 minutes
- Connect manometer to SimCube in a closed circuit with inflation bulb.
- Inflate circuit to 100mmHg on calibrated manometer.
- Adjust SimCube NIBP potentiometer until SimCube reads 100mmHg, +/- 1%. Note that the NIBP potentiometer can be accessed with a small screw driver via a hole in the top of the SimCube's aluminum case about ¾" back from the front face. Disassembly of the SimCube is not necessary.
- Deflate and allow re-zeroing. (Approximately 10 seconds.)
- Re-pump and check 100mmHg again. Adjust potentiometer again if necessary.
- Check calibration at 50, 150, 200, 300mmHg, +/- 1%
- Re-install the SimCube's blue rubber boot.

8.1.3 Manometer Calibration Process for SC-5

- Precheck calibration at 100, 200, 400mmHg, -100, -200, -400mmHg, to+/- 0.5mmHg. Normally no adjustment will be required. Proceed with the following steps only if it is found that adjustment is required.
- Remove the SimCube's blue rubber boot.
- Power up SimCube for calibration and allow to warm up for 3 minutes
- Connect manometer to SimCube in a closed circuit with inflation bulb.
- Vent to atmosphere and press calibration button, S2.
- Inflate circuit to 100mmHg on calibrated manometer. Allow for settling and adjust to exactly 100mmHg.
- Press calibration button. Note that the calibration button can be accessed without disassembling the unit. Use a non-metal probe such as an orange stick to press button.
- Inflate circuit to 400mmHg on calibrated manometer. Allow for settling and adjust to exactly 400mmHg.
- Press calibration button.
- Deflate to 0mmHg
- Using 60cc syringe, create a vacuum and adjust to –100mmHg. Allow for settling and adjust to exactly -100mmHg.
- Press calibration button.

- Repeat for –200, -300, -400mmHg.
- Check calibration at 100, 200, 400mmHg, +/- 0.5mmHg.
- Check calibration at -100, -200, -400mmHg, +/- 0.5mmHg.
- Re-install the SimCube’s blue rubber boot.



8.2 ECG CALIBRATION

8.2.1 Required Equipment

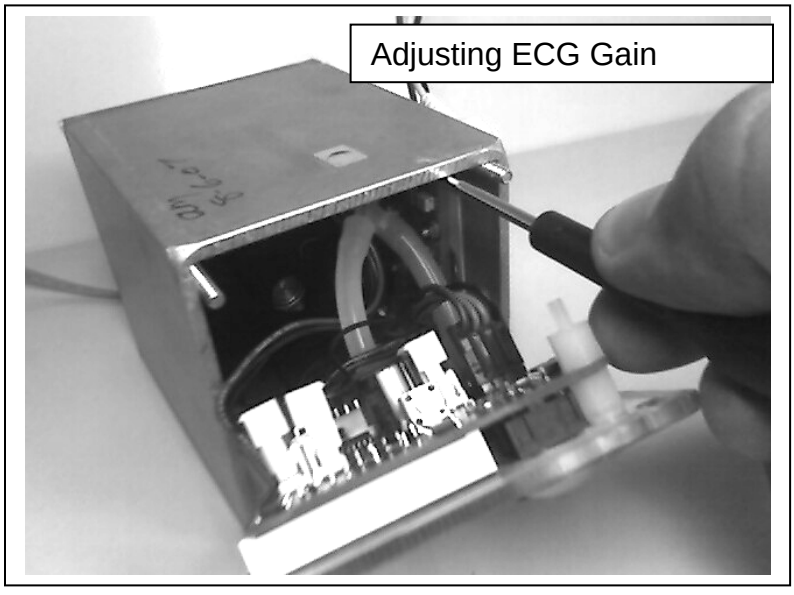
An ECG monitor, capable of generating a strip chart recording with 1mV=1cm scaling, in current, traceable calibration, and the appropriate ECG cable. If needed, Pronk Technologies can provide a schematic for a simple circuit to calibrate and ECG monitor from a calibrated DVM.

8.2.2 Calibration Process

- On the Monitor, disable the ECG filter and Recorder Delay. Place in lead I.
- Precheck the ECG calibration. Normally no adjustment will be required.
- Some SimCubes are calibrated with 1mV on Lead I while others are calibrated with 1mV on Lead II as follows:

Model	SC-1	SC-2	SC-3	SC-4	SC-5
Cal on Lead II for Software above	1.10.0	1.10.0	3.2.0	3.2.0	4.2.0

- ECG size should be 1mV +/-5%. Proceed with the following steps only if it is found that adjustment is required.
- Remove the SimCube's blue rubber boot.
- Remove the four acorn nuts and pull back the Face Plate assembly
- Adjust ECG pot until R-wave equals 1mV on recorder +/- 5%
- Replace the Face Plate assembly (see disassembly/ assembly instructions
- Replace the four acorn nuts
- Re-install the SimCube's blue rubber boot.



8.3 IBP CALIBRATION

8.3.1 Required Equipment

An invasive blood pressure monitor in current, traceable calibration, and the appropriate adapter cable.

8.3.2 Calibration Process

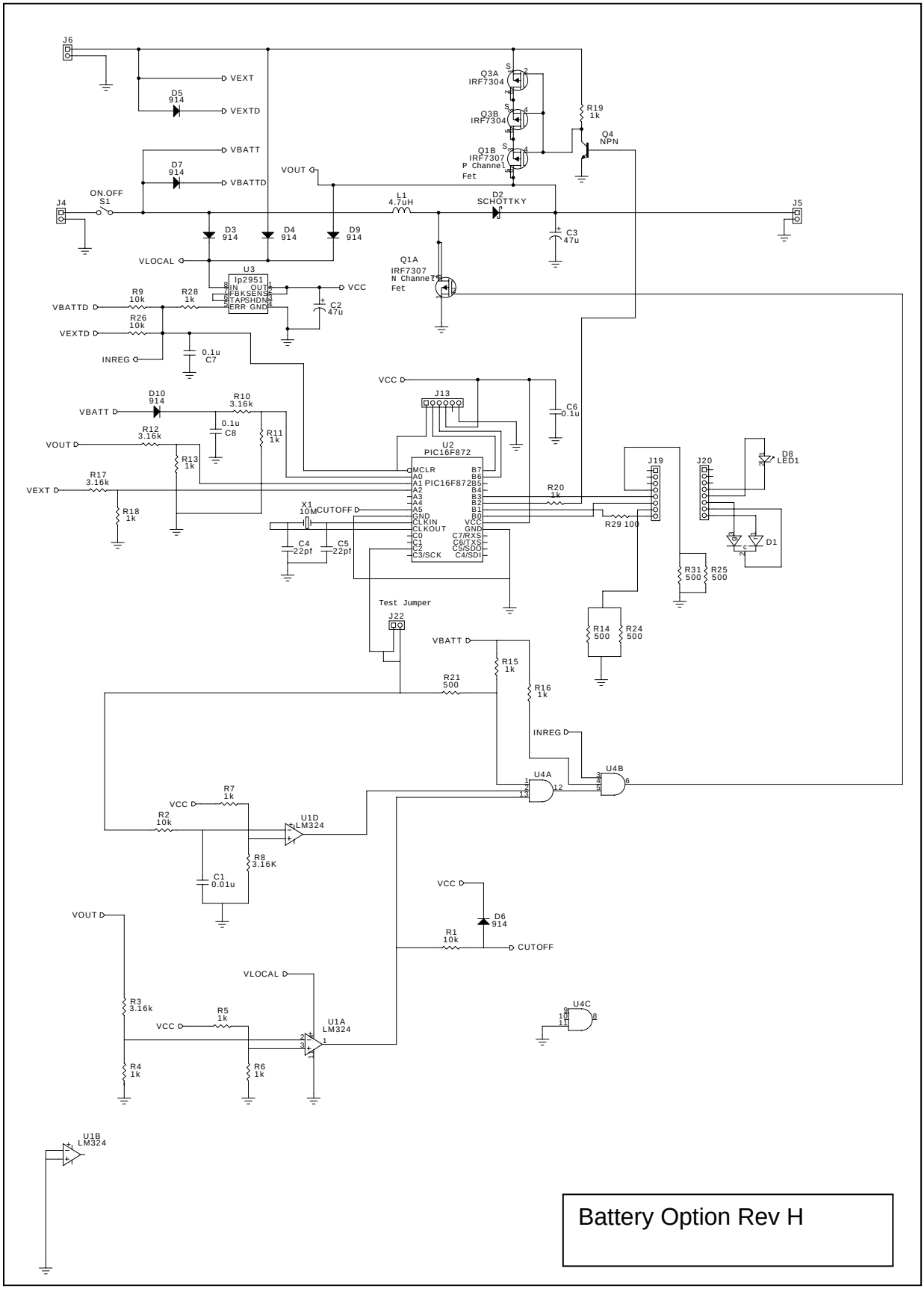
The Calibration of the SimCube's IBP circuit is set with fixed 0.1% resistors so there is no adjustment. If the reading is out of specification the unit has a failure and must be repaired.

- Hook up the IBP adapter cable to the monitor and the SimCube.
- Select the SimCube mode which shows 0 mmHg in the IBP column.
- Zero the IBP on the patient monitor.
- Select the SimCube mode which shows 100mmHg in the IBP column.
- The reading on the patient monitor must be 100mmHg.

9. The Battery Boost Option

The schematic diagram for the Battery Boost Option PCBA is show below. The purpose of this module is to provide the 6VDC require by the SimCube from a pack of 4 AA batteries whose voltage can vary from 6VDC to 2.5VDC depending on discharge level. The module also automatically switches over to the external power supply when that is plugged in and displays battery and external power supply status.

- The external power supply is connected at J6, the battery pack connects and J4 and the output of the module is on J5.
- The internal power supply signal is VCC which is regulated by regulator J3. U3 takes its power (VLOCAL) from and or'd combination of external power supply voltage, battery pack voltage, and the module's output voltage. Running on the module's output voltage is important in that it means the module can continue to operate even when the battery voltage drops too low to support its internal electronics.
- The heart of the module is the boost converter formed by L1, Q1A, D2, and C3. When Q1A is on current flows through L1 to ground. When Q1A is turned off the voltage on output of L1 rings up over its input voltage. The spike generated by this ringing is captured by D2 and C3.
- The switching of L1 is controlled by the microcontroller U2 which can adjust the width and frequency of the switching based on battery and load conditions.
- Several limit conditions, such as a maximum duty cycle limit and a maximum voltage limit are evaluated by the comparators formed by U1, and gated into the switching waveform by U4A and B.
- When the external supply is connected the boost converter is turned off and the external supply voltage is switched to the output by Q3A, Q3B, and Q1B. Note that three FETS are used for this switch because the internal body diode in the FETs conduct the output voltage back to the external supply input and the voltage drop generate by the body diode of a single FET is not enough for the microcontroller to accurately assess whether it is seeing an active external supply or body conduction of the output voltage.
- Battery status is displayed on D1 and external power supply status is displayed on D8.


J6
VEXT
D5
914
VEXTD
VBATT
D7
914
VBATTD
VOUT
ON.OFF
S1
J4
L1
4.7uH
D2
SCHOTTKY
J5
D3
914
D4
914
D9
914
C3
47u
VLOCAL
U3
lp2951
IN OUT
FEEDBACK
SHUTDOWN
ERR GND
VCC
C2
47u
R9
10k
R28
1k
R26
10k
VBATTD
VEXTD
INREG
0.1u
C7
Q3A
IRF7304
Q3B
IRF7304
Q1B
IRF7307
P Channel
Fet
R19
1k
Q4
NPN
Q1A
IRF7307
N Channel
Fet
VCC
J13
C6
0.1u
D10
914
VBATT
R10
3.16k
0.1u
C8
R11
1k
R12
3.16k
VOUT
R13
1k
R17
3.16k
VEXT
R18
1k
U2
PIC16F872
MCLR
A0
A1
A2
A3
A4
A5
GND
CLKIN
CLKOUT
C0
C1
C2
C3/SCK
B7
B6
B5
B4
B3
B2
B1
B0
VCC
GND
C7/RXS
C6/TXS
C5/SDO
C4/SDI
X1
10M
CUTOFF
C4
22pf
C5
22pf
R20
1k
R29 100
J19
J20
D8
LED1
D1
R31
500
R25
500
R14
500
R24
500
Test Jumper
J22
VBATT
R15
1k
R21
500
R16
1k
INREG
U4A
U4B
R7
1k
VCC
R2
10k
U1D
LM324
R8
3.16K
C1
0.01u
VCC
D6
914
R1
10k
CUTOFF
VOUT
VLOCAL
R3
3.16k
R5
1k
VCC
U1A
LM324
R4
1k
R6
1k
U4C
U1B
LM324
Battery Option Rev H

10. SimCube System Troubleshooting Tips

SYMPTOM	SOLUTION
Readings inconsistent or no reading at all	If using Battery Boost be sure the Batt On/Off switch is ON and Batt Level LED is green. If Level LED is Red or dark, replace batteries with fresh set.
Readings inconsistent, error message (C05) on Welch Allyn 52000	Reduce/Control cuff volume and movement by using Pronk Cuff Jacket Duo or inserting cuff inside 2" tube.
During NIBP simulation, monitor continually inflates cuff without reading	Check for leak in hose and cuff. Use standard adult size cuff only for adult and hyper modes. Use 3-4 fingers of space in center of cuff (or use Cuff Jacket Duo). Neo mode requires size 3 or 4 (8-13cm) cuff to be effective.
Alaris / IVAC 4410 does not get readings	This device calculates diastolic during inflation. Wait until it is done with its first inflation cycle; it will automatically restart inflation and will get reading.
IVAC 4200 does not get readings	The IVAC 4200 is primarily an auscultatory blood pressure monitor, in fact there is a microphone built into the cuff itself. However, these monitors also have an oscillometric algorithm and will get consistent readings if you remove the cuff from the hose and connect the hose directly to the SimCube simulator.
Can't get RESP waveform on Datascope	Reconfigure snaps to the following: black lead to white RA, red lead to black LA and white lead to green RL.
Battery Boost Option does not charge batteries	This is by design. In order to allow customers to use off the shelf alkaline batteries, no charge current is applied to the batteries being used.
Readings are always high/low on specific model/manufacturer	Each model of monitor has a different algorithm for calculating NIBP values; therefore different models even from the same manufacturer can yield different results. Use the SimCube Sample Reading chart as a reference.
Respiration does not count	The amplitude of the respiration signal was carefully selected to ensure that monitors will not count if 60hz noise is present. Some monitors may require an adjustment to increase resp size in order to get an accurate respiration rate.
SimCube won't read 0000 (shows ----) at power up	During power on initialization, SimCube auto szeroes pressure itself. Therefore, vent circuit to atmosphere at power up and wait 15 seconds for auto zero to complete, signified by 0000 on display.
Can't connect 12 Leads to snaps	Order ECG snap extender, part number EXTEND.
10.1.1.1 Unable to resolve problem	Contact Pronk Technologies Technical Support at: (800) 541-9802

11. Parts List

Service Assemblies	Description	
SC-5 Main PCBA	Main PCBA for SC-5 with software	
SC-1 through 4 Main PCBA	Main PCBA for SC-1 through 4. Specify model for software.	
ECG Housing Assembly	ECG/Resp PCBA installed in SimCube housing	
Motor assembly	SimCube motor assembly with serial number, interrupter assembly and pneumatics assembly	
Interrupter assembly	Interrupter harness, mounts on motor assembly	
Power Harness Assembly	Power harness for SimCube	
Pneumatics assembly	Pneumatics assembly for installation on motor assembly	
Battery Option case assembly	Battery option case service replacement. Includes top, bottom and face parts.	
SC-5Faceplate/bottom kit	Set of 1 SC-5 faceplate and bottom plates, with bulkhead. Specify graphic overlay.	

12. Accessories (Prices subject to change without notice)

P/N	DESCRIPTION	PRICE (USD$)
ADAPT-D	**DINAMAP/Critikon style**: A threaded screw-on connector, used on Critikon and MDE monitors.	40.00
ADAPT-M	**Marquette style**: A freely-rotating twist-on connector, used on GE/Marquette monitors.	40.00
ADAPT-Q	**Quick Disconnect**: A push-pull quick disconnect connector used on HP monitors.	40.00
ADAPT-L	**Luer**: A friction-based connector used on Spacelab monitors and most neonatal monitors.	40.00
EXTEND	**ECG Snap Extenders**: If using 12-lead clips instead of snaps to connect to the SimCube, a set of Snap Extenders is recommended.	40.00
ADAPT-B	**Bulb Adapter** - This hand bulb adapter is utilized in static calibration, as well as in Peak Detect Mode for SimCube models SC-3 and SC-4.	40.00
CASE	**Nylon Carrying Case** - When using your SimCube system outside the shop, this padded nylon carrying case is recommended for added security and holds all your adapters nicely .	50.00
LARGE CASE	**Large Nylon Carrying Case** – This case is for use with the **SC-5** and all accessories. It is large enough to hold all the IBP adapter cables, battery Module, NIBP adapters and more.	80.00
CUFF JACKET DUO	**Cuff Jacket -** Slide the NIBP cuff inside our patent-pending Cuff Jacket to create a controlled and repeatable cuff volume without the need for bulky mandrels. Use of the larger Cuff Jacket is suggested for optimum repeatability on most monitors. The small Cuff Jacket is required on a few older NIBP monitors such as Welch Allyn 52000 series.	40.00
IBP-EXTENSION	**IBP Extension Cable** – This six foot long extension cable allows you to use any of the interface cables below.	20.00
IBP-MERLIN	**IBP Interface Cable for Merlin** –This cable has a six pin mini-DIN to Merlin style connector. It is six inches long and works with the IBP-Extension cable.	80.00
IBP-DATASCOPE	**IBP Interface Cable for Datascope Monitors** – This cable is used to interface to Datascope monitors. It has a six pin mini-DIN to Datascope connector. It is six inches long and works with the IBP-Extension cable.	80.00
IBP-GE	**IBP Interface Cable for GE/Marquette Monitors** – This cable is used to interface with GE monitors. It has a six pin mini-DIN to GE style connector. It is six inches long and works with the IBP-Extension cable.	80.00
IBP-MDE	**IBP Interface Cable for MDE/Spacelabs** – This cable is used to interface with MDE and Spacelabs monitors. It has a six pin mini-DIN to MDE/Spacelabs style connector. It is six inches long and works with the IBP-Extension cable.	80.00

13. Services (Prices subject to change without notice)

SERVICE ITEM NUMBER	DESCRIPTION	PRICE (USD$)
SC-1/3 Upgrade Service	SC-1 to SC-3 Upgrade	150.00
SC-1/4 Upgrade Service	SC-1 to SC-4 Upgrade	450.00
SC-2/4 Upgrade Service	SC-2 to SC-4 Upgrade	150.00
SC-2/5 Upgrade Service	SC-2 to SC-5 Upgrade	900.00
SC-3/4 Upgrade Service	SC-3 to SC-4 Upgrade	300.00
SC-4/5 Upgrade Service	SC-4 to SC-5 Upgrade	750.00
Warranty-SC-1	Extended Warranty* – 1 year	96.00
Warranty-SC-2	Extended Warranty* – 1 year	112.00
Warranty-SC-3	Extended Warranty* – 1 year	104.00
Warranty-SC-4	Extended Warranty* – 1 year	120.00
Warranty-SC-5	Extended Warranty* – 1 year	140.00
Calibration Service SC-1 / SC-3	Full checkout and calibration incl. certification	100.00
Calibration Service SC-2 / SC-4 / SC-5	Full checkout and calibration incl. certification	120.00
Rejuvenation	SimCube Rejuvenation Service: - Complete checkout, calibration and certificate and multiple part replacement, depending on wear. - Boot replacement	283.00

*Extended Warranty (up to 5 years total) may be purchased only at time of original sale or with purchase of Rejuvenation Service

14. Warranty and Service Information

SimCube Limited Warranty

The SimCube NIBP Simulator with optional ECG/Respiration and IBP feature is warranted against defects in materials and workmanship for a period of thirty-six (36) months from the date of shipment to the original purchaser. Warranty is valid only to the original buyer. Defective equipment should be returned freight prepaid to Pronk Technologies Inc. Equipment returned with defective parts and assemblies shall be either repaired or replaced at the manufacturer's sole discretion. This warranty is not applicable if the unit has been opened, if repair has been attempted, if the unit has been damaged due to operation outside the environmental and power specifications for the product, or due to improper handling or use.

If any fault develops, notify Pronk Technologies (*see Returns and Repairs, below*) giving full details of the difficulty, and include the model and serial number of the device. Upon receipt of shipping instructions, forward the device prepaid and repairs will be made at the factory.

The foregoing warranty is in lieu of all other warranties expressed or implied, including but not limited to any implied warranty or merchantability, fitness or adequacy for any particular purpose or use. Pronk Technologies shall be liable only for repair or replacement of the SimCube NIBP Simulator and optional features. Pronk Technologies shall not be liable for any incidental or consequential damages.

ORDER CANCELLATION AND REFUND POLICY

You may return your item within 14 days of delivery for a full refund. We are unable to exchange items (however, if you received a defective or incorrect item, we will be happy to make an exchange). Item(s) returned for refund must be in its original condition, undamaged and with no missing parts, packed in its original packaging, and include both the original receipt and an RMA number.

We will notify you via e-mail or fax of your refund once we have received and processed the returned item. You can expect a refund in the same form of payment originally used for purchase within 7 to 14 business days of our receiving your return.

RETURNS AND REPAIRS

Please call Pronk Technologies' Service Department at 800-541-9802 to obtain a Return Merchandise Authorization (RMA) number and the shipping address. Returns should be packaged securely in the original packaging materials. The RMA number should be clearly marked on the packaging. If the return is for a new item and is a result of our error, we will make arrangements for payment of return shipping. Otherwise, items should be returned freight prepaid to Pronk Technologies.

Sample Readings

Different manufacturers, different models and sometimes even different software versions can give quite different readings, but the following are some average values obtained from a variety of devices.

Model	Systolic	Diastolic	Systolic STD Dev	Diastolic STD Dev
Alaris 4410	128.7	77.7	3.0	3.7
Alaris 4510	120.3	79.0	4.6	1.8
Colin BP8800C	116.8	78.0	1.3	1.2
Critikon 8700	118.3	78.9	2.8	3.0
Critikon 1846SX	117.0	79.0	0.7	0.0
CSI	123.0	82.0	N/A	N/A
Datascope Accutor	119.9	73.0	4.2	2.9
Datascope Passport	118.5	72.6	0.8	2.3
Draeger	119.7	79.0	0.6	1.0
Fukuda Denshi	118.6	78.5	0.5	0.4
GE Dash 3000	120.3	78.7	2.9	1.2
GE Pro200	107.0	82.6	2.9	4.0
GE Pro 400	113.1	73.6	5.0	5.2
GE Pro 400 V2	120.0	80.9	4.0	1.0
GE/Marquette Solar 8000	119.8	81.3	1.0	1.7
HP Merlin	113.0	74.0	3.1	4.3
HP Viridia	120.0	72.7	1.5	2.2
IVAC4200	118.5	82.0	0.7	1.4
J & J	117.0	79.0	N/A	N/A
Marquette Eagle	114.2	78.7	1.8	0.7
MDE E300	117.9	78.8	1.5	1.0
MDE Prism	119.0	82.6	1.2	0.7
Nihon Khoden	110.1	80.1	0.8	1.2
Philips Heart Smart	108.1	77.1	2.8	1.0
Phillips Intelliview	119.7	80.7	1.2	4.2
Phillips M8007	116.7	77.7	0.6	1.5
Spacelabs 90369	114.9	78.3	0.9	0.8
Welch Allyn 52000	121.4	83.8	2.8	2.8
Welch Allyn VS	116.1	83.1	3.2	3.2